TROPOS
Leibniz Institute for Tropospheric Research

ACTRiS

Intercomparison of Mobility Particle Size Spectrometers

Project No.: MPSS-2015-1-2

Basic information:

Location of the quality assurance: TROPOS, lab: 118

Delivery date: October 05, 2015

Setup in the laboratory: October 05, 2015

Comparison period: October 05, 2015 – October 12, 2015

Principal Investigator	Home Institution	Participant	Instrument
Braban, Christine	NERC Centre for Ecology and Hydrology; Bush Estate, Penicuik, EH26 0QB Country: UK	Sarah Leeson, Marsailidh Twigg	UK TSI-MPSS: TSI Electrostatic Classifier, model 3080 # 71050230 (Dec. 2010) TSI CPC Model 3775 # 71105009 (Jan. 2011)

Summary of Intercomparison:

Pre-status:
The UK TSI-MPSS did not pass the quality standards of ACTRIS and GAW.

Final status:
The UK TSI-MPSS did not pass the quality standards of ACTRIS and GAW. It is necessary to apply again after repair by TSI-company.

From October 05, 2015 to October 12, 2015, the UK TSI-MPSS participated the TROPOS ACTRIS-2 Workshop. The workshop consisted of an entrance test and a final run. In addition to the overnight ambient measurements, we had numerous high voltage checks, zero- and PSL- measurements. The report is divided into three sections. The first section shows the Pre-Workshop-Status of Reference Instruments the week before. The second section explain the laboratory setup, list of components and the PSL measurement. After that, we show for each run the time series of the particle number concentration, correlation plots to the reference total particle counter, and the particle number size distribution. As reference standards, we used the CPC model TSI 3010 for total particle number concentration and two TROPOS mobility particle size spectrometer. The particle counters have been calibrated against a calibrated TSI electrometer 3068 B with the serial number 70838596.

A TSI 3080 classifier (Serial: 71050230, Date: Dec 2010) with a long DMA (TSI 3081) and a TSI 3775 CPC (Serial: 71105009, Date: Jan 2011) have been in operation at Auchencorth Moss since August 2012. Since operations began there has been a drift in the recorded distributions, with an increase in particle number with decreasing diameter over time. The system used a closed loop vacuum system with 2 Perma Pure driers in series to generate sheath air and provided a third drier, the sample drier, with a counter flow of dry air. The sample drier was built inhouse and used ¼" copper tubing using a Perma Pure MD gas dryer.
On arrival at TROPOS, the unusual distribution was noted when running on ambient. A blank was done but a leak was detected. To ensure the distribution problem was due to instrumentation and not related to drier set up, the sample drier was removed but the impactor remained. On removing the driers the tube connecting the sheath flow to DMA was also replaced from the ¼" long tube to a shorter 1/2" diameter. When investigating the setup, the classifier was found not to be connected to the computer and therefore no classifier parameters had been previously recorded when operated in the field. This explains a communication error message that the system had back in the field but the operator had chosen to ignore the warning. The set up was modified in order that the TSI operating software could communicate with the classifier.
During the initial runs at TROPOS is was noted that the TSI AIM software started reporting a scan at 14nm, whereas on the front panel of the TSI 3080 started at ~36 nm with a starting voltage of ~ - 80 Volts. A number of procedures were carried out to identify the source of the voltage error.

- 06/10/15 1500 – the impactor was removed from the classifier
- 06/10/15 manually on the front panel of the classifier the voltage set to – 10 Volts and measured by independent voltmeter at the output of the classifier. This was correct.
- 06/10/15 1600 Ran with 3772 CPC with a sheath flow of 5.0 lpm to see if the problem was with the CPC communications. Same problems appeared.
- 07/10/15 Put back in our 3775 CPC. Sheath flow set to 3.0 lpm and sample to 0.3 lpm.
- 07/10/15 Changed PC as TSI had suggested that observed voltage could be software related. No improvement. Returned to original laptop.
- 08/10/15 - positive voltage supply put in. No effect. Scan started at +80V,~38 nm.
- 08/10/15 – tested voltage on cable input from CPC. CPC sending correct mV signal but front panel voltage on classifier is not correct.
- 09/10/15 – Changed power supply back to negative. Appears to be a drop in starting scan voltage, now ~ 40V with ~ 20 nm.

- 09/10/15 - Tried to modify the zero on the motherboard. 23 turns on the screw of the motherboard with intermittent calibrations using hyperlink. → offset is still the same, but the whole size distribution was decreased.
- Aerosol inlet nafion dryer (homemade from CEH) is replaced by stainless steel instead of copper.
- In the final run the UK TSI-SMPS is out of the 10%.

List of Components

	Specification	Reference System Line1	UK TSI-SMPS
Position (Line)		1.6	1.4
Company		TROPOS	TSI 3080
Software		TROPOS 5.5	Aerosol Instruments 9.0
CPC		Model 3772	Model 3775
Flow ratio		1.0 : 5.0	0.3 : 3.0
Source		Kr85	TSI Kr85 (TROPOS)
HV cassette		positive	negative
DMA		Hauke medium	Long DMA TSI 3081
Flow meas.	Aerosol	✓	✓
Dryer		✓	✓ homemade
RH sensor	Inlet	✓	✓
T sensor		✓	✓
RH sensor	Sheath air	✓	✓
		✓	✓
T sensor		✓	✓
Dryer		✓	✓ 2 x Perma Pure driers
p sensor		✓	x

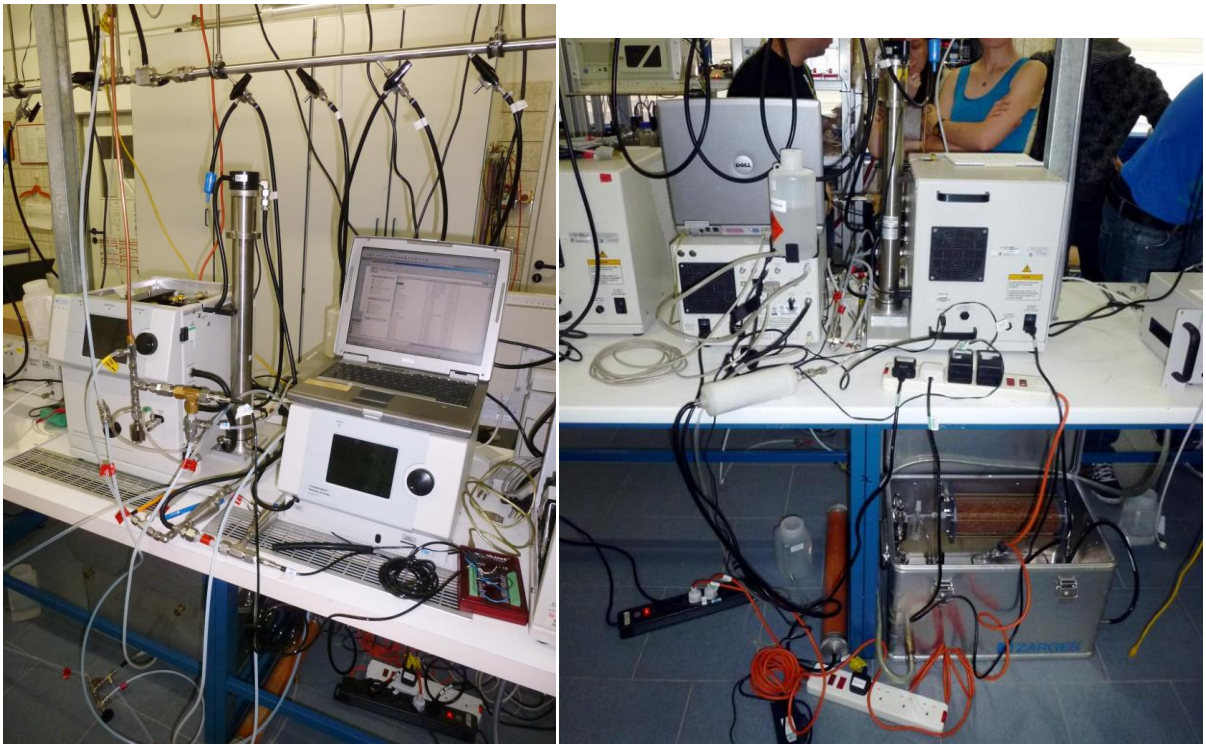
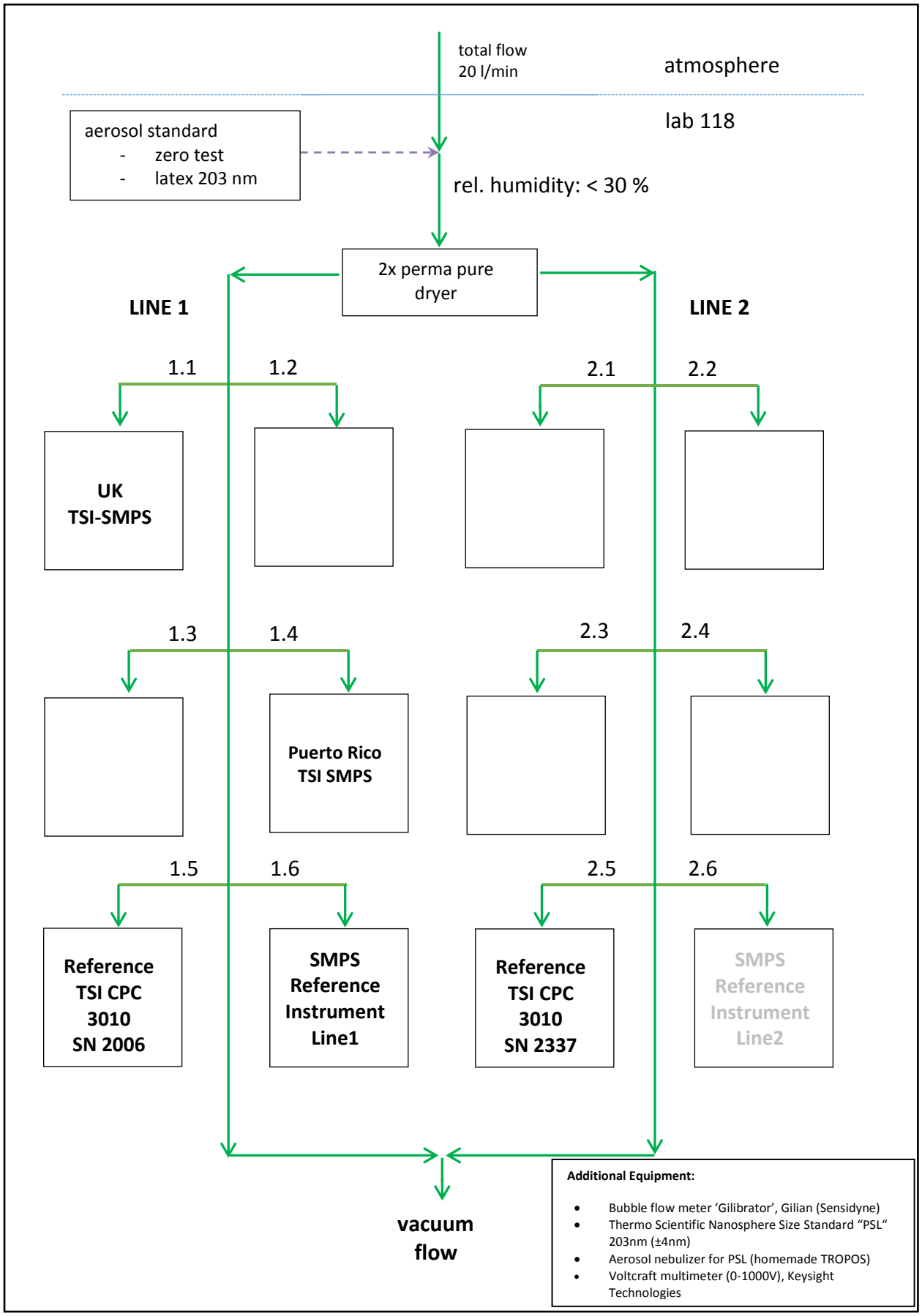


Figure 01: Setup: UK TSI-SMPS is shown from the front and back with sheath air system in the TROPOS lab.

Laboratory setup



Pre-Workshop-Status of the Reference Instruments (23.09.2015 – 24.09.2015)

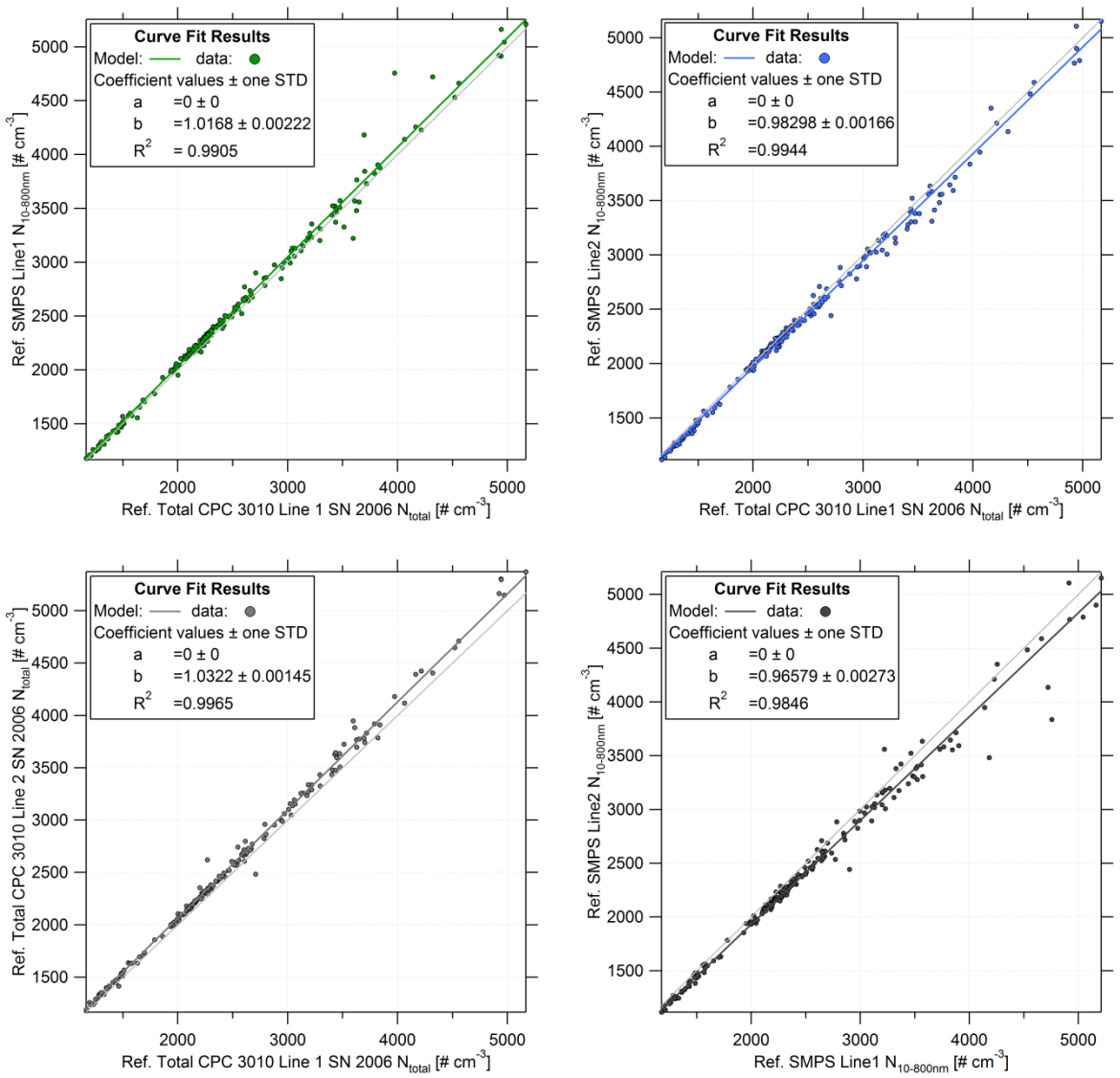


Figure 02: Correlations of the TROPOS Reference SMPS systems and TSI Total CPCs Model 3010 of both lines (see laboratory setup). Multiple charge, internal diffusion loss and CPC flow corrections are included.

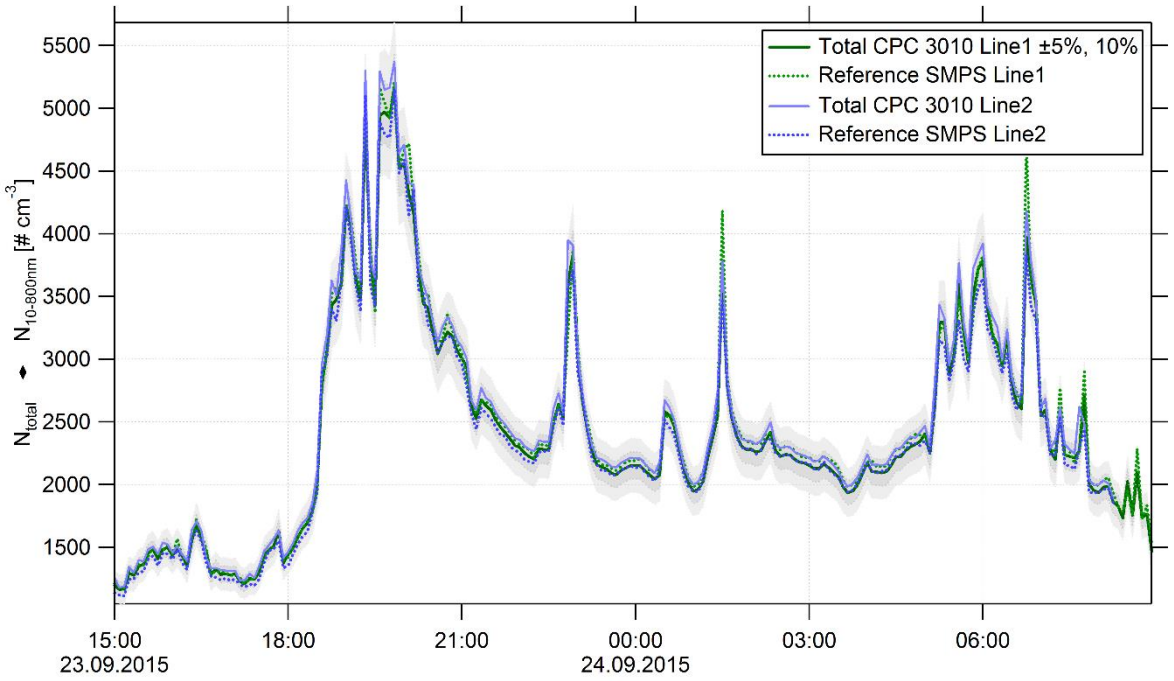


Figure 03: Intercomparison between the two Lines. For each Line there is a TROPOS Reference SMPS and a TSI Total-CPC Model 3010, which are calibrated against an electrometer. Multiple charge, internal diffusion loss and CPC flow corrections are included.

Pre-Workshop-Status of the Candidate (05.10.2015 – 06.10.2015)

Institut	System	Components	CPC Model + Serial No.	Line	Flow		Zero	
TROPOS	Ref1	SMPS	3772 SN 71011009	1.6	**1.040**	l/min	0	# cm^{-3}
TROPOS		Total CPC	3010 SN 2006	1.5	**1.035**	l/min	0	# cm^{-3}
TROPOS		Total CPC	3010 SN 2337	2.5	**1.022**	l/min	0	# cm^{-3}
CEH	UK	TSI SMPS	3775 SN 71105009	1.4	**0.357**	l/min	0	# cm^{-3}

Latex scan 203nm

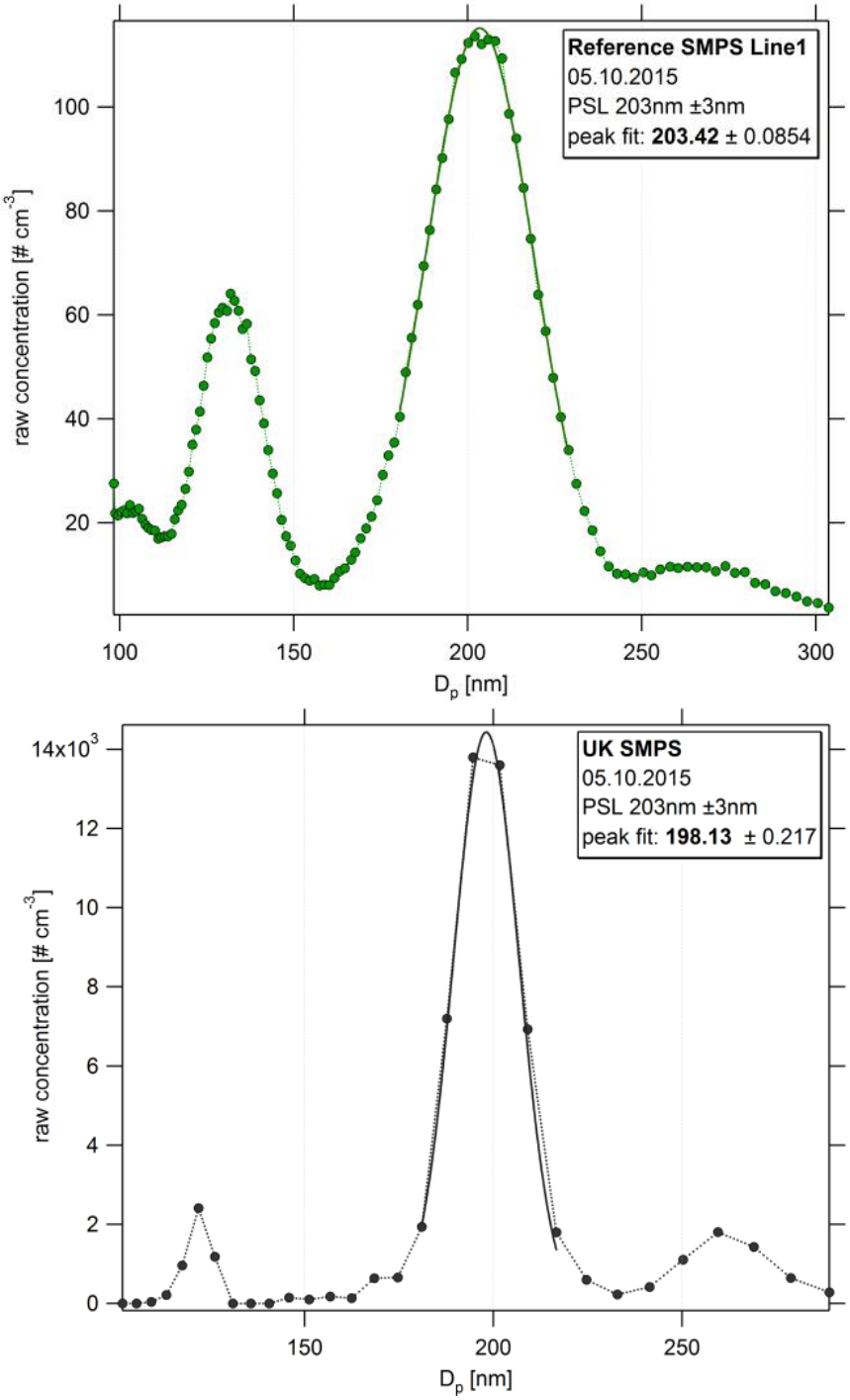


Figure 04: Measurement of latex 203 nm for TROPOS Reference Instrument Line 1: Particle size distribution (raw concentration) for latex 203 nm on October 05, 2015.

- **Stettings UK TSI-SMPS:**
  - ✓ impactor 1962
  - ✓ source → DMA → CPC 3775 (for diffusion loss correction)
  - ✓ flow ratio 0.3:3

Time Series

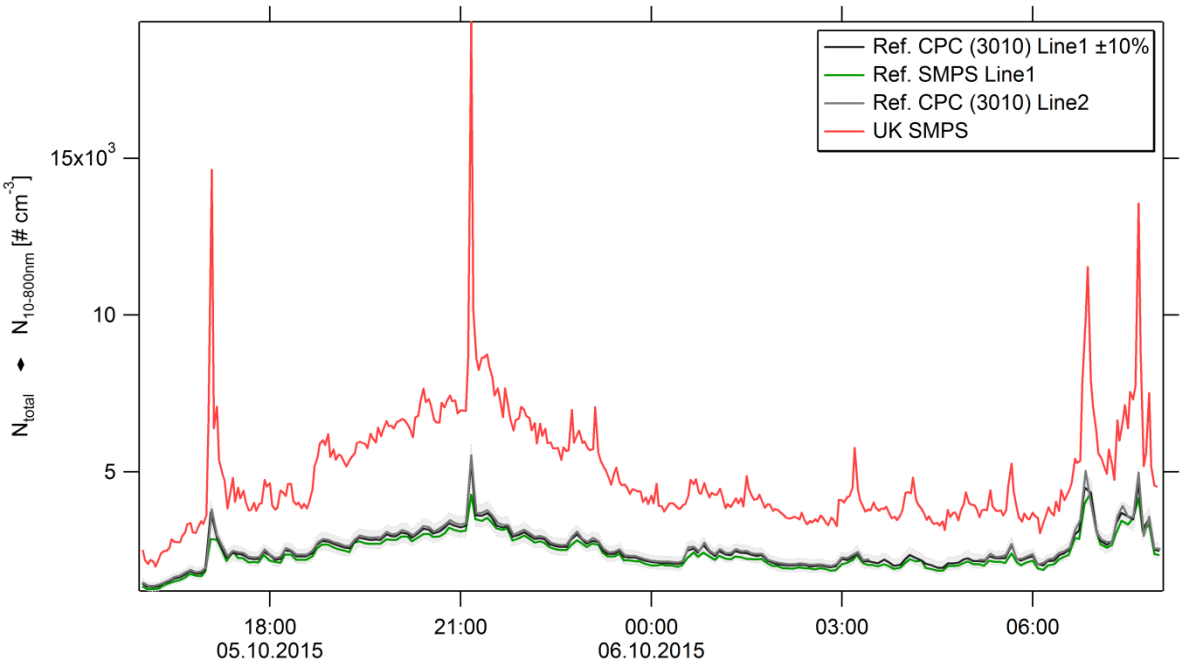


Figure 05: Time series (October 05, 2015 15:20 pm – October 06, 2015 08:00 am) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the SMPS and total number concentration (N_{total}) of the CPCs. Multiple charge correction is included. Additionally included in Reference SMPS are internal diffusion loss and CPC flow correction.

Correlation between the reference CPCs

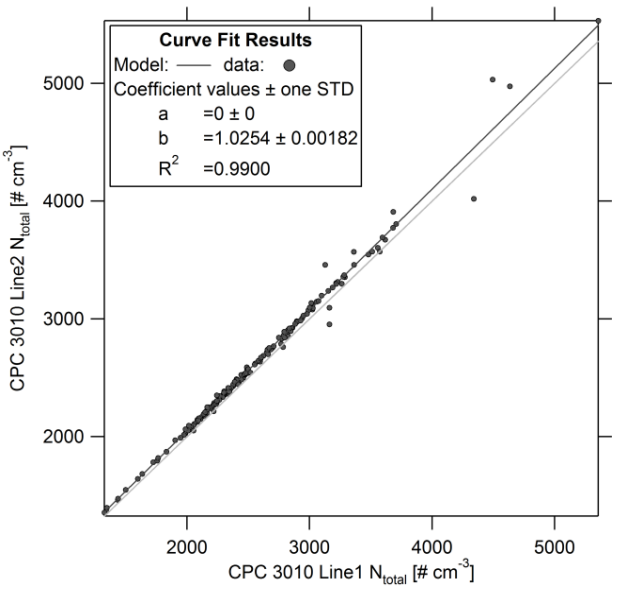


Figure 06: Linear regression between two TROPOS total Reference CPCs Model 3010 from October 05, 2015 16:00 pm until October 06, 2015 08:00 am.

Correlation between the reference CPC and TROPOS Reference Instrument Line 1

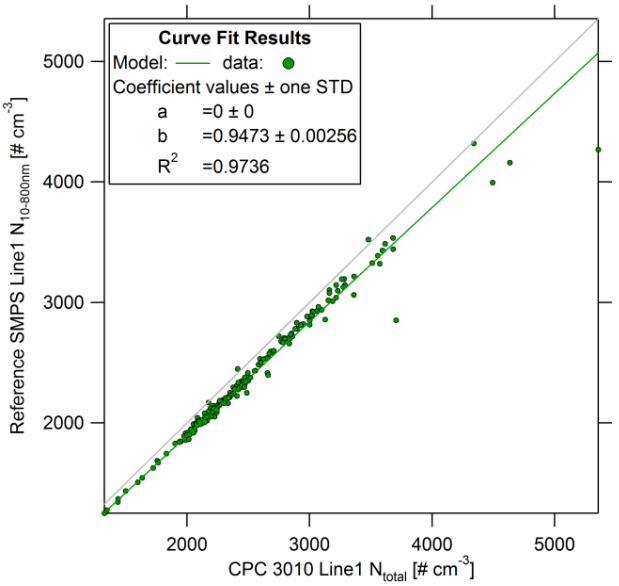


Figure 07: Linear regression between the number concentrations of the TROPOS reference instrument line 1 and TROPOS reference CPC in line 1 from October 05, 2015 16:00 pm until October 06, 2015 08:00 am. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Particle Number Size Distribution

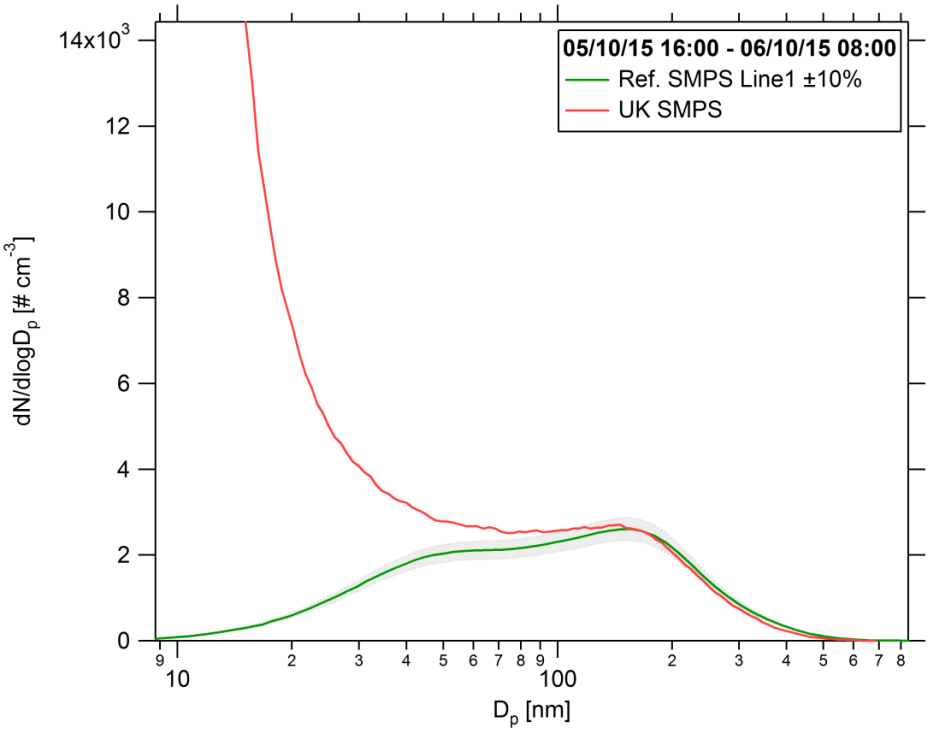


Figure 08: Comparison of mean particle number size distribution of UK TSI-SMPS and TROPOS reference instrument line 1 from October 05, 2015 16:00 pm until October 06, 2015 08:00 am. Multiple charge correction and CPC efficiency are included. Additionally included in Reference SMPS are internal diffusion loss and CPC flow correction.

Final Status of the Candidate (10.10.2015 – 12.10.2015)

Institut	System	Components	CPC Model + Serial No.	Line	Flow		Zero	
TROPOS	Ref1	SMPS	3772 SN 71011009	1.6	**1.044**	l/min	0	# cm^{-3}
TROPOS		Total CPC	3010 SN 2006	1.5	**1.043**	l/min	0	# cm^{-3}
TROPOS		Total CPC	3010 SN 2337	2.5	**1.024**	l/min	0	# cm^{-3}
	UK	TSI SMPS		1.1	**0.30**	l/min	0	# cm^{-3}

Time Series

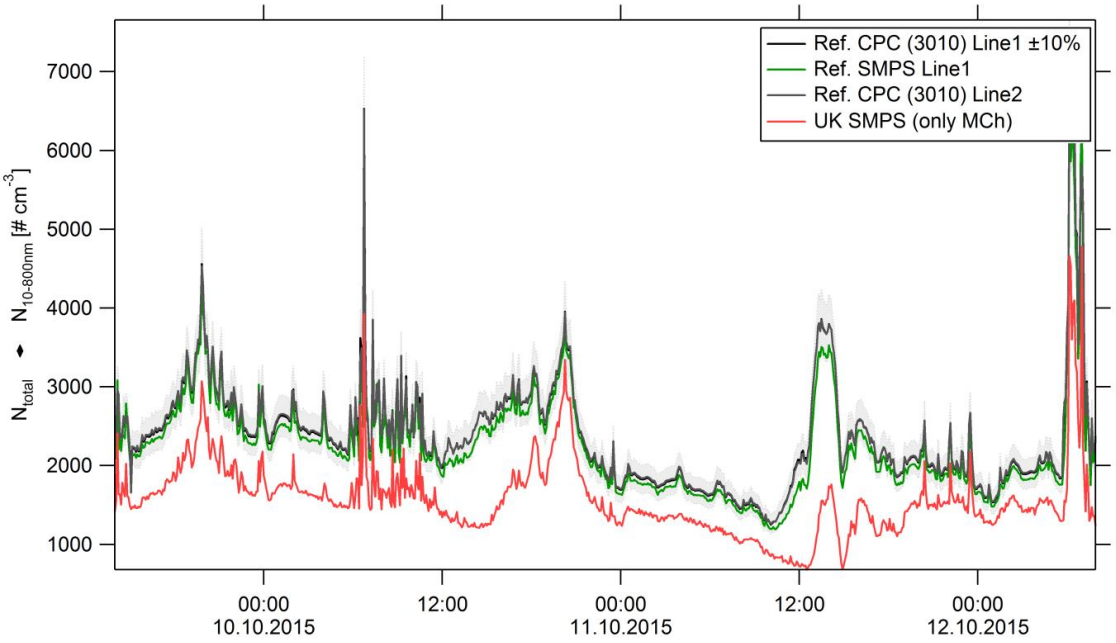


Figure 09: Time series (October 10, 2015 14:00 pm – October 12, 2015 08:00 am) of the integrated particle number concentration ($N_{10\text{-}800nm}$) of the SMPS and total number concentration (N_{total}) of the CPCs. Multiple charge correction is included. Additionally included in Reference SMPS are internal diffusion loss and CPC flow correction.

Correlation between the reference CPCs

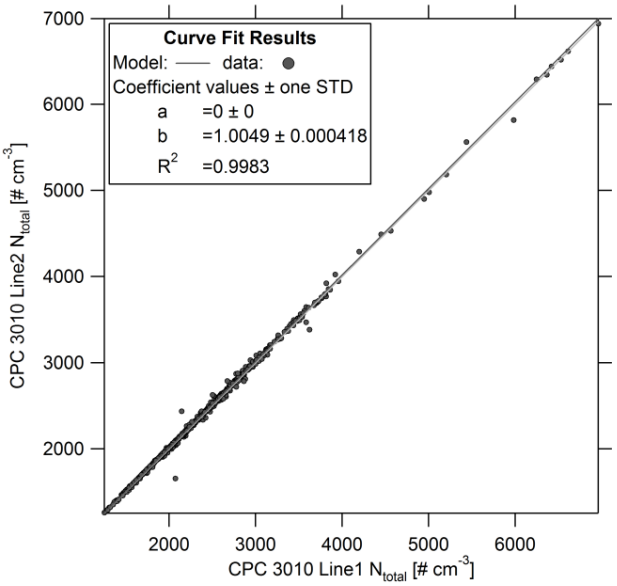


Figure 10: Linear regression between two TROPOS total Reference CPCs Model 3010 from October 09, 2015 14:00 pm until October 12, 2015 08:00 am.

Correlation between the reference CPC and TROPOS Reference Instrument Line 1

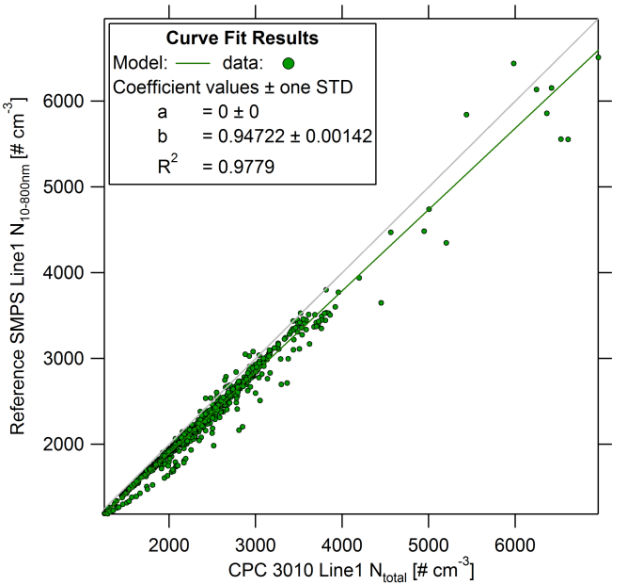


Figure 11: Linear regression between the number concentrations of the TROPOS reference instrument line 1 and TROPOS reference CPC in line 1 from October 09, 2015 14:00 pm until October 12, 2015 08:00 am. Multiple charge correction, internal diffusion losses and flow corrections are included.

Correlation between the reference CPC and UK-TSI SMPS

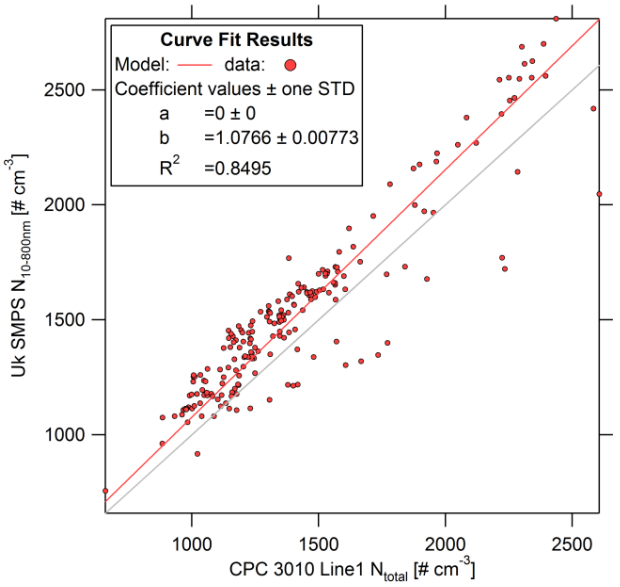


Figure 12: Linear regression between the number concentrations of the UK TSI-SMPS and TROPOS reference CPC in line 1 from October 09, 2015 14:00 pm until October 12, 2015 08:00 am. Multiple charge correction, internal diffusion losses and CPC flow corrections are included.

Particle Number Size Distribution

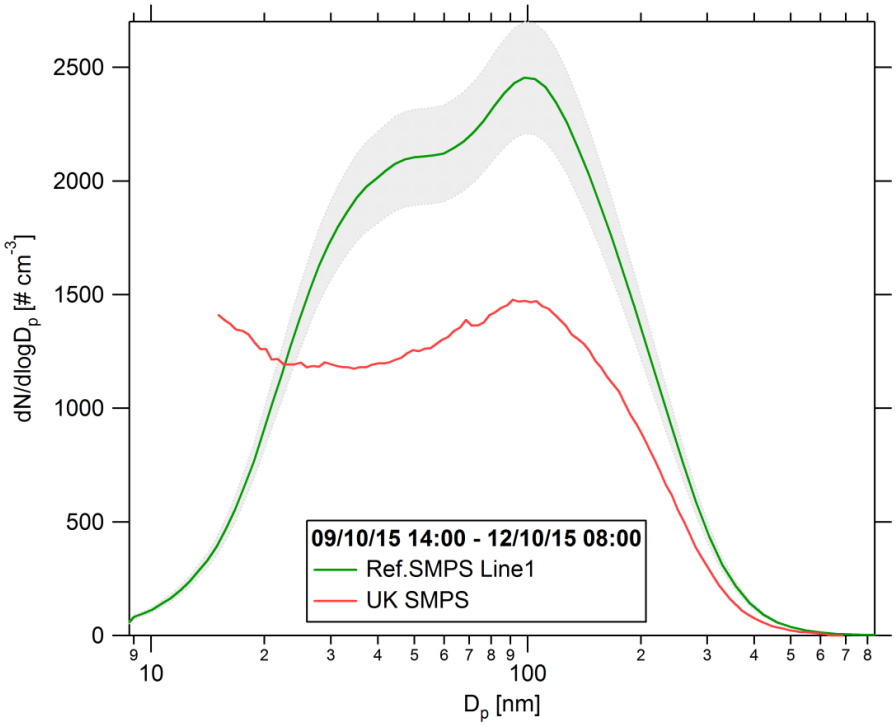


Figure 13: Comparison of mean particle number size distribution of UK TSI-SMPS and TROPOS reference instrument line 1 from October 10, 2015 14:00 pm until October 12, 2015 08:00 am. Multiple charge correction and CPC efficiency are included. Additionally included in Reference SMPS are internal diffusion loss and CPC flow correction.